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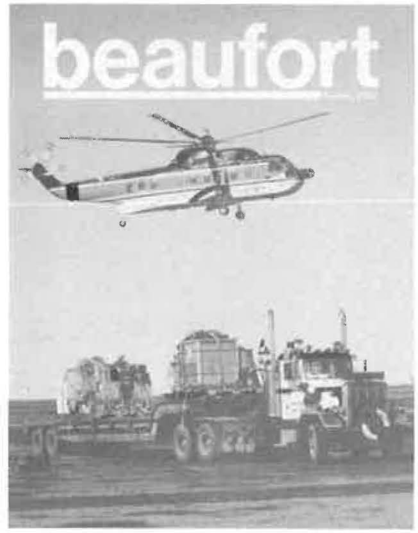

Cover Photograph: *Two of the most important transport vehicles for Beaufort Sea operations are illustrated on the front cover. Large semi-trailers and tandem units drive north on the Dempster Highway carrying vital supplies, and 26 passenger Sikorsky S-61s fly oil workers to the offshore drilling sites.*

Beaufort is published by Dome Petroleum Limited, Esso Resources Canada Limited and Gulf Canada Resources Inc. to provide the general public, and interested parties, background information on the long range development and production of hydrocarbons from the Beaufort Sea and Mackenzie Delta. In terms of engineering and technical skills production is attainable in this region by the mid-80s. Before approval in principle is obtained from the federal government, a detailed report on the possible effects and impacts of such production must be prepared This report, known as the Environmental Impact Statement, is to be completed in the summer of 1982. The E.I.S. will address the issues and concerns raised by the production scenario. BEAUFORT will report on the progress of the E.I.S. and the energy industry's evolving plans to address these concerns.

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The Shorebase System and Support Network

All the previous editions of **Beaufort** Magazine have been based upon a subject theme, such as tankers, pipelines and artificial islands. In this edition we examine the shorebase system and support network that is essential to offshore exploration and production. In telling the story of the search for oil, it is often overlooked that the search would not succeed without an enormous variety of services and technical support systems. The shorebase infrastructure, the trained people who run it, and the transportation and communication facilities linking the frontier region of the Beaufort to southern Canada are essential.

An aerial view of Esso's Tuktoyaktuk base facilities, including harbour and gravel strip for STOL transport aircraft.

Presently, the major shorebase facilities in the Beaufort region are located at Tuktoyaktuk and McKinley Bay, although a variety of sites have been used by the major operators in the past ten years, and several more are being considered for future production facilities. The people that work at these shorebases rely upon transport aircraft and helicopters for mobility, and the workers on the offshore drillships and islands fly to work and come home in helicopters. Drilling supplies, machinery, fuel and food travel north on large barges up the Mackenzie River, on semi-trailer trucks over ice roads, and by ships through the Bering Strait. High priority freight is transported in passenger aircraft, converted for cargo loads, or in cargo planes specialized to carry bulky loads. Knitting the whole support system together is communications, by data link and computers, microwave transmitters, telephone lines, and space satellites.

Offshore drilling relies on a fleet of modern, well equipped and specially designed marine vessels. Those vessels require their own navigation systems, weather and ice forecasting, maintenance engineering support, and drydock facilities - all this support is provided to the fleet from the northern support bases. The positioning of drillships over well sites, the manoeuvreing of supply boats and larger vessels in the shallow waters and dredged channels of the Beaufort, and the building of artificial islands call for high technology positioning and survey methods.

The story of the support pillars to offshore exploration is contained in this edition. Our readers will also find an article on northern resource management of the domestic reindeer and wild muskox, important and promising activities in northern Canada, which will likely expand in future years on the same land that is being used by the oil industry for support services.

Environmental Impact Statement (EIS) Status - August 1982

By the time our readers receive this edition of **Beaufort**, the seven volume Environmental Impact Statement (EIS) will have been published and all people on the FEARO mailing list will have received their copies.

The EIS has been written for both lay and specialist readers and addresses the possible effects and impacts of projected activities related to the production of oil from the Beaufort Sea-Mackenzie Delta region. Members of the general public who wish to read the EIS will find copies of the seven volumes at public libraries in locations such as Edmonton and Calgary, Alberta, Whitehorse and Dawson City, Yukon, and Tuktoyaktuk, Inuvik, Yellowknife, Norman Wells, and Fort Simpson, NWT. Smaller northern communities such as Holman Island, Pangnirtung, Pond Inlet, and Sachs Harbour will have copies of the EIS at the local settlement office.

The main hearing for the Environmental Assessment and Review Process (EARP) are presently expected to begin early in 1983. They represent the most important next step in the overall process leading to the orderly development of the north's resources for the benefit of all Canadians.

Aerial view of the DEW Line site at Tuktoyaktuk, N.W.T. Photo courtesy H. Palmer.

During the many discussions and debates that arise today about energy mega-projects both in the Arctic and elsewhere in Canada, it is frequently overlooked that a mega-project of unprecedented scale took place along the Arctic coast more than 25 years ago. The building of the DEW (Distant Early Warning) Line radar and communications system across 3,000 miles of Arctic terrain was considered an enormous and almost impossible engineering task, when first proposed in 1952. During the summer of that year a study group from the Massachusetts Institute of Technology recommended that a chain of radar warning stations be built as far north as possible, thereby providing maximum advance warning of an attack by enemy bombers.

To evaluate the technical concept and the construction methods demanded, the Bell System of Companies was contracted by the U.S. Air Force to build experimental stations in Alaska. A division of Bell, Western Electric Company, was appointed general manager of Project 572, as it came to be called. The feasibility of Arctic radar stations was proven during 1953, but not without some trial and error in the construction of buildings. It was found that metal panels, used in other northern military installations, caused electrical interference with the sensitive communications and radar equipment. Metal clad buildings tended to leak and were more readily crushed by snow, and battered by strong Arctic winds.

Instead of metal, wood was substituted, eliminating electrical problems and forming better waterproof seals. To minimize the on-site labour requirements in the harsh winds and cold temperatures, the buildings were constructed in the south as modules; with each module normally measuring 4.8 metres (16 feet) wide, 8.5 metres (28 feet) long and 3 metres (10 feet) high. As many as 50 modules were linked together to form the main radar stations; these were connected in long parallel 'trains', joined in the middle by a catwalk. The buildings were aligned with the prevailing wind and raised above the ground so that blowing snow would pass underneath rather than piling against the buildings in drifts.

Several designs were evaluated

for protecting the large radar antennae. The final solution looked particularly appropriate for the Arctic landscape, in that it resembled an Eskimo igloo. The large plastic sphere, called a geodesic dome, consisted of 361 triangular prefabricated segments bolted together. It proved to be an excellent weather-tight structure for the Arctic and became the characteristic 'trade-mark' of DEW Line stations from Alaska to Greenland.

In December, 1954, after the feasibility studies and tests were complete, Western Electric Company was contracted to build the complete chain of more than 50 radar and communications stations stretching from Point Barrow, Alaska in the west, to Broughton Island on Baffin Island in the east. In the Canadian Beaufort region alone, DEW Line stations were established at Komakuk Beach, Stokes Point and Shingle Point in the Yukon, and Tuktoyaktuk, Atkinson Point (McKinley Bay) Nicholson Island, Cape Perry (Wise Bay) in the Northwest Territories.

The U.S. Air Force gave Western Electric a 32 month deadline - the Line had to be operational by July, 1957. The deadline was met! Two years and eight months later the chain of stations was complete.

The mammoth task required the transportation of approximately 460,000 tons of materials, construction equipment and electronic gear to the Arctic. The majority of the cargo went by sea, in the largest ship convoys ever assembled in peacetime. During the brief Arctic summer of 1955, 120 ships sailed north, one convoy of 57 leaving Seattle, Washington, heading through the Bering Strait, and a second convoy leaving Halifax, Nova Scotia, led by the H.M.C.S. Labrador, the first Canadian deep draft icebreaker to make a successful journey through the Northwest Passage.

The 1955 season was particularly severe, and ice-choked passages were a challenge for the relatively thin-skinned freighters and landing craft being used to carry supplies.

Buildings at DEW Line sites were modularized, joined to form parallel wings with a connecting, elevated walkway. The characteristic geodesic dome is conspicuous all across the Arctic from Alaska to Greenland. Photo courtesy of FELEC Services, Inc.

The mist rises off the Arctic permafrost tundra in late spring, caused by the thawing of the swampy surface layers. Most DEW Line sites had to be built on pilings or gravel pads to protect the permafrost, and ensure stability for the buildings and towers all year round. Photo by W. Ralph.

The Labrador, along with the U.S.S. Edisto icebreaker, provided the brute force necessary to break the ships loose from the ice. Despite this opposition, the western convoy sailed into the Beaufort Sea and dropped supplies at selected sites along the Canadian coastline, as far east as Shepherd Bay, on south Boothia Peninsula.

The eastern convoy deposited its supplies at locations on Baffin Island, Southampton Island and on the Melville Peninsula. A total of 129,000 tons were delivered in the sealift of 1955, during what proved to be one of the most difficult ice seasons on record. By comparison, the sealifts of 1956 and 1957 had an easier passage, bringing another 150,000 tons of cargo, including much of the technical equipment and supplies to run the DEW Line stations for a full year.

One hundred and forty thousand tons of cargo were airlifted by civil and military aircraft to the Arctic, in what has been called the largest commercial airlift in history. In a period of 32 months approximately 45,000 commercial flights were conducted to the north, involving about 50 Canadian and 31 United States airlines and bush flying operations. Large military transports such as the C-119 Flying Boxcar and the C-124 Globemaster were supplemented by a host of smaller aircraft, many of which were equipped with skis to land at unprepared sites.

The air operation itself and the design of the DEW Line called for the building of an airstrip at almost all of the radar sites. In total some 26 million square feet (2.48 million square metres) of runways were built, forming an air link across the Arctic for re-supply. Twenty-five years later many of these runways are still being used by the DEW Line contractor, Federal Electric, the U.S. Air Force and others to fly in people and supplies on a routine basis. For example, the main airstrip at Tuktoyaktuk is being used actively by the public, as well as several of the major oil companies in support of offshore drilling activities.

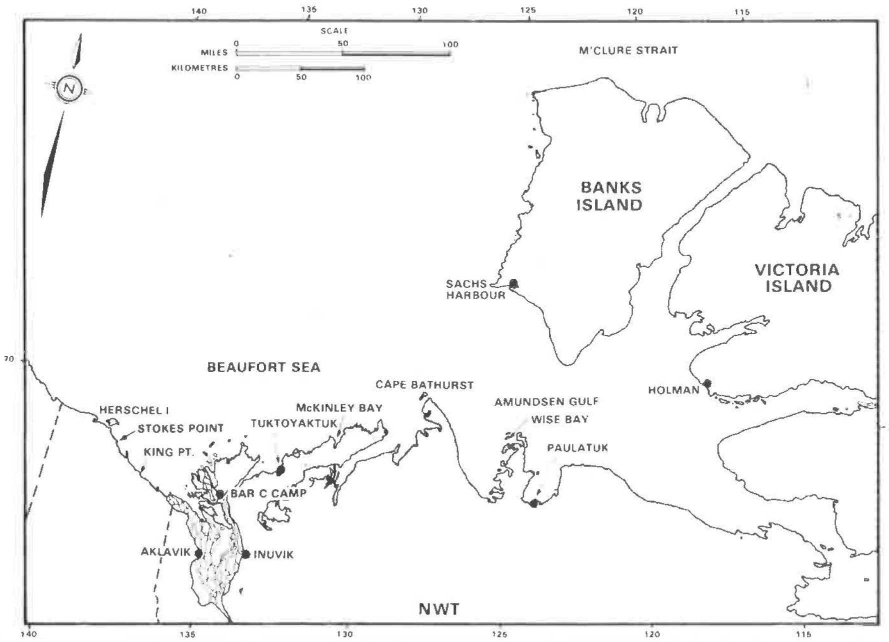
Many of the DEW Line stations are built upon permafrost, which required huge amounts of gravel insulation for roads, runways and buildings. Those buildings which were not raised on pilings driven deep into the ground rest upon a bed of insulating gravel up to 3.6 metres (12 feet) thick. Roads and runways required a gravel foundation up to 1.8 metres (6 feet) thick. The building of the DEW Line sites consumed 7.34 million cubic metres of gravel, enough to build a road between Vancouver and Toronto, 5.5 metres (18 feet) wide and 0.3 metres (one foot) thick.

A further idea of the scale of the DEW Line as an Arctic mega-project can be gained from the quantity of petroleum products sent north to the sites. Sixty three million Imperial gallons of fuel and oil were shipped, more than 36 million gallons in 818,000 steel drums aboard the ships during the summer convoys.The radar stations required 46,000 tons of steel. It has been estimated that the three main construction companies working on the Line employed more than 20,000 people, although at any one time there was a peak of 7,500 men working in the Arctic.

Altogether more than 4,600 companies provided supplies of one kind or another to the project, including about 22,000 tons of food consumed by the workers over 32 months. There were more than 113,000 purchase orders issued for supplies, representing $347 million. The building of the Line is estimated to have cost between $500 and $600 million, in 1957 value dollars, a figure that would be several times higher in today's inflationary economy.

Although the DEW Line has been surpassed by new radar surveillance methods, and may no longer be an impregnable defensive system against attacking bombers, it has stood the test of time in the harsh Arctic environment. Unfortunately, it has been largely forgotten as an engineering achievement. It was the first mega-project in the Canadian Arctic, and resulted in the network of stations and airstrips well north of the Arctic Circle which often seem, in fact, to blend with the Arctic landscape, rather than standing apart as a man-made achievement.

Description of the Shorebase Network



The major sites of present and possible future development are illustrated on this map of the Beaufort Sea region.

Over the many years that the oil industry has been exploring the Mackenzie Delta and Beaufort region, logistical support for these activities has been provided by a network of shorebases and marine docks. Currently the most important centre for these support systems is Tuktoyaktuk, where two of the major operators, Esso and Dome, have major facilities and Gulf is building a base of operations as well.

Esso established its Tuktoyaktuk base across the bay from the settlement, in 1969, and to support its expanding exploration program constructed a new 75 bed camp in 1981 which includes 11 offices, kitchen facilities, and a recreation room. The Esso base provides storage for drilling consumables such as well casing, drill pipe, drilling muds, and 8,694 cubic metres (two million gallons) of fuel in six large storage tanks. The base also has its own airstrip capable of handling aircraft up to the size of DeHavilland Twin Otters, as well as a mechanical shop, parts building and warehouse.

Until 1979 Esso operated Bar C camp, located at a former DEW Line site on the southern tip of Richards Island. It served as the main staging area for exploration drilling in the north Mackenzie Delta and the shallow waters of Mackenzie and Shallow bays. Although presently "moth-balled", the camp and all facilities could be readily reactivated in the future should they be required.

Gulf is currently building a support base at Tuktoyaktuk which will accommodate a permanent staff of 50 people, with layover capability for up to 150 personnel. Approximately 1,600 square metres (17,200 square feet) of space will be allocated to shop and warehousing requirements, as well as storage for aviation and diesel fuels in the order of 10,400 cubic metres (2,300,000 gallons).

Dome has a 19 hectare (47 acres) base facility at Tuktoyaktuk which has accommodation for up to 360 people. Eight hectares (19.7 acres) are devoted to storage and dock facilities. The other elements of the base include a plant for the production of oxygen and acetylene, required for welding operations, a secondary sewage treatment plant, steel fabrication and machine shop, a tank farm for the storage of fuel and warehouses for equipment and operational supplies.

Tuktoyaktuk has a fully equipped airport with an 1,525 metre (5,000 foot) long gravel runway suitable for jet transport aircraft. The airport is presently used mainly by Dome, and is as well equipped as many major airports in southern Canada, with hangar facilities for the maintenance of a variety of smaller aircraft and helicopters. Due to the many helicopters flying in support of offshore operations, Tuktoyaktuk has landing facilities for rotary wing and fixed wing aircraft. *(For a fuller description see our article in this edition on aviation support).*

The harbour at Tuktoyaktuk has a draft of about 4 metres (14 feet) and is equipped with several docks used by major companies. Due to the limited open water season and the high cost of repairs, not to mention lost productivity, the marine fleet of the various operators is serviced and overhauled (mostly during the winter months) using floating drydocks. In this way vessels do not have to travel to southern ports from the Arctic for annual maintenance and repairs.

The other major existing marine support centre is located at McKinley Bay, approximately 110 kilometres (70 miles) east of Tuk base on the Tuktoyaktuk Peninsula. McKinley currently functions as a medium

An aerial view of McKinley Bay, where drillships spend the winter months frozen in the ice. In the foreground is a portion of the artificial island built in the bay to form a base of operations, as well as a shelter for the ships. Photo by W. Ralph.

draft mooring basin for the drillships, supply vessels, dredgers, barges and the icebreaker, Kigoriak. The mooring basin covers about 100 hectares (247 acres) and is sheltered by a 63 hectare (155 acres) man-made island built up by using dredged material from the bay.

Navigation channels at McKinley were also dredged to allow deeper draft vessels to dock at the facility. The man-made island is equipped with a helipad and during the winter season, when McKinley Bay is an important base for resupply operations, a 1,800 metre (6,000 foot) runway is constructed on the ice of the bay to accommodate landings by large transport aircraft.

During the four months of relatively ice-free conditions, Tuk base is the most active centre of

This aerial view displays the layout of Tuktoyaktuk harbour, where ships can dock during the brief summer period, with NTCL's base facility in the foreground, Dome's base across the bay, and in the extreme background is Gulf's new facility under construction. Photo by H. Palmer.

operations, with approximately 360 people working and living there. During the long winter season when drilling is confined to artificial islands, activity at the Tuk base camp is reduced and much of the action is redirected to McKinley Bay. Here the ships of the drilling fleet undergo repairs and refits as required, with the help of floating drydocks previously mentioned. One of the largest floating drydocks in Canada is located in the Beaufort; named the Canmar Careen, it is a very important support system for offshore exploration because it eliminates the lengthy transit time and shortened seasons that would be involved if the ships of the fleet were serviced in the south. When the long Arctic winter finally ends, the fleet is ready to set sail to offshore locations for another busy season.

Future plans include replacement of the temporary barge dock at McKinley Bay with a permanent structure 100 metres (328 feet) long, and the construction of a major base in support of the first offshore production operations. This expanded base will provide many of the same kinds of functions presently undertaken at Tuktoyaktuk.

In the future, depending upon drilling success and the rate of development, one or more additional shorebases may be required in the Beaufort Sea region, at sites along the Yukon coast. Several locations in this area have deep draft access and are more suitable for a year round harbour. There is a major rock deposit at Mount Sedgewick, 40 kilometres (25 miles) inland from the Yukon coastline, which could provide foundation and armour material for the building of offshore production islands.

Major development at a Yukon location could take place, subject to government approval, in later years. Such development, should it occur, could also include the building of an airport accommodating jet transport aircraft, a road connecting the shorebase with the Dempster Highway at Fort McPherson, and a harbour able to handle deep draft vessels. At the peak of operations, assumed to occur in the 1990s, such a facility could support approximately 500 personnel, and might occupy up to 100 hectares (247 acres) of land.

Among the most promising locations are King Point and Stokes Point, both located southeast of Herschel Island, which in the 19th century was the mooring site for whaling ships hunting the bowhead. Herschel Basin is a natural deepwater location which could accommodate deep draft vessels and drilling units, and is easily accessible from the Yukon coastline. Stokes Point, which is being surveyed by Gulf, was formerly a DEW Line installation and has a station site, access road to fresh water, and an abandoned airstrip. Consequently, restoration of the Stokes Point site would result in minimizing additional site disturbance.

Floating drydocks are used in the Beaufort Sea to service and repair the marine fleet. In drydock in this photo is the icebreaker, Kigoriak. Photo by H. Palmer.

Renewable Resources of the Beaufort-Mackenzie Delta Region

The domestic reindeer are rounded up in the early summer with helicopters. This is done at Atkinson Point, within a short distance of McKinley Bay. In the background the drillships of the oil industry can be seen at anchor, awaiting the final breakup of the winter ice pack. Photo courtesy of Dr. D. Billingsley.

Reindeer Ranching and Muskox Research

Apart from the oil industry activities, the Mackenzie Delta and Beaufort Sea region has also been the scene of various commercial enterprises during the past 90 years based upon the harvesting of the north's renewable resources. Obvious examples include fur trapping and fishing and, in the 19th century, bowhead whaling. Enterprises have come and gone over the years, but a few have survived as community 'cottage' industries. One of the success stories in harvesting renewable resources is the domestic reindeer herd located in the Mackenzie Reindeer Grazing Reserve. This reserve covers approximately 46,620 square kilometres (18,000 square miles) and includes within its boundaries all of the present major oil industry shorebases, including the operations at Tuktoyaktuk and McKinley Bay, and various onshore drilling sites such as Atkinson Point, Mayogiak, Parsons Lake and others.

The story of the domestic reindeer in Canada dates back to a 1921 Royal Commission by the federal government, which recommended the establishment of reindeer ranching to provide employment and a reliable source of meat and hides for northern natives. In 1929 the government took the initiative in establishing a herd in the western Arctic by purchasing 3,400 reindeer in Kotzebue Sound, Alaska and contracting to have them herded east to the Mackenzie Delta.

The reindeer drive from Alaska took six years to complete, in the face of enormous geographic obstacles and a harsh climate. The responsibility for bringing the animals to Canada was undertaken by experienced Lapland reindeer

herders. The difficulties encountered on that 2,600 kilometres (1,600 miles) journey are reflected by the fact that of the 3,400 reindeer to leave Alaska less than 2,400 made it to the Delta. Fortunately, about 800 fawns were born in the first season in Canada, making up much of the journey's loss.

For the next four decades the reindeer ranching operation survived but was not a conspicuous commercial success. The herd gradually grew in numbers up to about 7,000 during the 1960s, with fairly wide fluctuations over the years. In 1974, the government decided to stop subsidizing the herding operations and sold the entire herd to the chief herder. After 1974, efforts were made to sell more reindeer meat in the Delta, and to develop a market for reindeer antlers in the Orient. These marketing efforts were intensified after the herd was sold again in 1977 to a new company called Canadian Reindeer (1978) Ltd..

The Department of Agriculture of the federal government worked with Canadian Reindeer (1978) Ltd. to build a portable slaughter house facility in the north that would meet federal health and inspection standards. The result was a 12 metre (40 foot) long tent which could be used when the temperature was below -18 degrees Centigrade (0 degrees Fahrenheit) and when set up over a source of potable water.

The slaughter house allowed the commercial sale of reindeer meat to outlets in southern Canada. The herd has prospered in recent years, numbering 10,000 in 1979 and 14,000 in 1981. The slaughter facilities were expanded and improved, with shipments of meat travelling south via the newly completed Dempster Highway. A second market was developed for the antlers of the reindeer which, ground up in a powdered form, are considered an aphrodisiac in the Orient.

In June of every year a round-up takes place, using helicopters for corralling the animals. Helicopters are quite effective and eliminate the use of all terrain vehicles which might damage the tundra. This roundup is conducted on the shores of McKinley Bay, in close proximity to the overwintering harbour for Dome's offshore fleet. A herd count is completed at this time, the antlers of the bulls are removed, and some males are castrated to provide steers for the winter harvest. Through a selective breeding and culling program, the reindeer herd is now felt to be healthier and more robust than earlier generations.

With the improved commercial outlook, Canadian Reindeer (1978) Ltd. has been able to finance the acquisition of a light, fixed wing aircraft for aerial surveillance and a bulldozer for maintenance of an airstrip. In the winter months snowmobiles are used to monitor the herd's condition and movements.

Up to four herders are on duty with the herd at any one time, although during the summer round-up as many as 50 people may be employed for two to three weeks, and 20 to 25 people for the harvest which takes place around February. The reindeer operations employ

An adult muskox may exceed 350 kilograms (800 pounds). This ancient animal evolved during the Ice Age, and is most at home in cold Arctic regions. The animals in this picture were photographed on Ellesmere Island. Photo by B. Keating.

local northerners living in the Delta, and charter aircraft and helicopters from locally based aviation companies.

The recent success of domestic herding after 50 years of slow progress is encouraging for the future. However, the operations have only recently become profitable, and close monitoring and analysis is necessary to maintain viability. In the last couple of years the reindeer reserve has been surveyed using sensing equipment to check for over-grazing. With the large increases in the herd, there may be a danger that reindeer moss, essential for winter forage, will not regenerate in the permafrost quickly enough to sustain the larger population. At present, about 3,000 reindeer are slaughtered annually to keep the herd below the 15,000 mark, and eliminate overgrazing.

The northern ranching of reindeer may have potential spin-offs. For example, it has been suggested that a small herd of reindeer could be located near Inuvik or Tuktoyaktuk as a tourist attraction. It may also be possible in the future to establish a meat processing plant in a northern centre, to maximize local resource harvesting, or perhaps set up a small dairy industry producing hormone-free milk and other dairy products.

The young muskoxen taken from Banks Island are shown here, being bottle fed at Tuktoyaktuk base camp, during a three day stopover on their way to the University of Saskatchewan in Saskatoon.

The Muskox Research Program

Although the domestication of caribou for reindeer herding is well proven, there is another northern wild mammal that may have similar potential for resource harvesting. That mammal is the muskox *(Ovibos moschatus)*. Although its scientific name translates to mean musky sheep ox, in fact, the muskox has no musk glands. It is related to both sheep and cattle, being of the family Bovidae. The species is an ancient one which evolved during the Ice Age, and is most at home in cold Arctic regions. In the 19th century the muskox was hunted for its woolly hide, which was made into lap-robes, and for its meat. Due to this hunting the animal was exterminated in Alaska and endangered in Canada. In 1917 the Canadian government declared them a protected species and, today, there are an estimated 40,000 to 50,000 muskoxen scattered throughout the coastal regions of the Northwest Territories and the High Arctic islands. The revival of the muskox in Canada is one of the more conspicuous examples of the success of conservation programs.

The muskox has been thriving on Banks Island in the Beaufort Sea, so much so that the species may be over-populating the large, 38,850 square kilometre (15,000 square miles) island situated at the western approaches of the Northwest Passage. Caribou and muskoxen populate the island and Bankslanders are concerned that over-population by the muskoxen may threaten both species, and jeopardize the livelihood of the local people.

In 1981 the Northwest Territorial government, in cooperation with the Inuvialuit Development Corporation (IDC), the Sachs Harbour Hunters and Trappers Association (Sachs Harbour is the only community on Banks Island, with a population of 150), the G.N.W.T. Wildlife Service and the Western School of Veterinary Medicine at the University of Saskatchewan established a management and research program

Since their arrival at the University of Saskatchewan's Western College of Veterinary Medicine, the baby muskoxen have grown rapidly, and have become accustomed to human handling. Photos courtesy of J. Rowell.

for muskoxen.

An experimental harvest of the animal took place on Banks Island in 1982. Approximately 100 animals were harvested over three days, producing a large quantity of top-quality meat. The muskoxen were herded into a corral, allowing the selection of younger animals. The corral, made of burlap and rope, contained the animals, who appeared content to feed and sleep inside the corral rather than attempt to escape.

Post mortems were conducted and biological samples collected to obtain scientific information about the health and breeding condition of the Banks Island muskoxen. The animals were examined in the field during the spring, 1982 harvest operations, and 13 new-born muskoxen were flown from Banks Island to Tuktoyaktuk by an Inuvik Coastal Airways Twin Otter. Dome Petroleum flew them from Tuk to Edmonton, Alberta and Athabaska Airways flew them to Saskatoon, Saskatchewan.

The young muskoxen, seven males and six females, weighed about 23 kilograms (50 pounds) when only a month old, and in June of this year they were still being bottle fed about 2.5 litres of milk a day, supplemented by hay. When full grown, a male muskox may weigh as much as 346 kilograms (800 pounds). Six of the calves are in a pen under "semi-isolation" conditions, and the remaining seven are outside in a small facility close to horses and cattle. According to Jan Rowell, coordinator of the research program at the University of Saskatchewan's Western School of Veterinary Medicine, the young muskoxen have grown accustomed to humans and are being handled frequently in order to tame them. This group will form the nucleus for a research herd of about 20 muskoxen, and will be bred upon reaching sexual maturity, in two or three years.

Although the initial research program at the Western College of Veterinary Medicine has been funded by "seed-money" from the Donner-Canadian Foundation for a three year period, the herd will be owned by the Sachs Harbour Hunters and Trappers Association and the Northwest Territorial Government. This initiative for the research study on young muskoxen originated with the Dean of the Western College of Veterinary Medicine, Dr. Nielsen, and two members of the faculty, Drs. Peter Flood and John Iversen.

The wool from the muskox is cashmere-like and can be spun very fine; it is considered to be one of the finest natural fibres from any animal. It is this fine undercoat which may form the basis for a commercial muskox herding operation. An adult muskox sheds about 3½ kilograms (6 pounds) of the wool, which forms a warm layer underneath the animal's outer guard hairs. Strands of the wool can be seen clinging to tundra shrubs and plants throughout the Arctic during springtime. The undercoat is so gossamer-fine that about 100 grams (4 ounces) will make a dress!

The early indications from the experimental harvest at Banks Island, and the research underway at the University of Saskatchewan, point to the feasibility of muskox herding. Both the meat and wool of the muskox are high quality and either, or both, may be marketable. Within a few years it may be possible to create a northern muskox herd, providing employment for northern residents.

Aircraft and Helicopters –Their Importance to Northern Operations

To shuttle oil workers to the Beaufort Sea operations, the major oil companies rely on large transport aircraft, such as Dome's Boeing 737 shown landing, or Esso's Lockheed Electra parked on the ramp in the background. Photo by G. Watson.

How Aviation Supports Beaufort Sea Explorations

Aircraft are an essential link in the transporation chain from southern Canada to the Mackenzie Delta and Beaufort Sea. The movement of people and high priority freight is entirely dependent upon fleets of airplanes and helicopters. Aviation opened up the north in the bush flying days prior to World War Two, and aircraft were used by Esso back in 1921 to explore for oil in the Norman Wells region. Today, aviation support is still important to exploration activities taking place in the Canadian Arctic.

The most important function of airplanes and helicopters for oil industry activities is to move people. Personnel employed by the industry in the Beaufort (not to mention other locations around the world such as Hibernia on Canada's east coast, Prudhoe Bay in Alaska, and the North Sea and Gulf of Mexico) work on a shift rotation basis. Working schedules vary dependent upon speciality or occupation, but the majority of personnel work a 14 to 18 day period, 12 hours a day, in the north. They are then flown home to southern Canada (or in the case of northern residents, to their Arctic community) for 7 to 14 days off. The transportation of support staff and seasonal workers to and from the Beaufort requires a variety of airplanes and helicopters.

The major companies in the Beaufort - Dome, Esso and Gulf - operate and charter a wide variey of airplanes and helicopters in support of exploration activities. For shuttle flying between southern Canada and the Beaufort, long range transports are used, such as Esso's Lockheed Electra turboprop,

Dome's Boeing 737 jet, as well as the transports of the scheduled air carriers. The most common landing fields in the Mackenzie Delta region ar Inuvik, which has a Transport Canada operated airport with paved runways, or Tuktoyaktuk, which has a well equipped airport with a 1,525 metre(5,000 foot) gravel surfaced runway. McKinley Bay, in the winter months, is also a landing destination for passenger and cargo flights from the south; an 1,800 metre (6,000 foot) ice runway is constructed on the frozen waters of the bay.

Esso's Electra and Dome's 737 are capable of flying freight and passengers in varying combinations, which provides additional flexibility for resupply operations. The freight carried can be quite diverse, ranging from machine parts and drill bits to perishable goods. During the spring break-up and fall freeze-up periods, when barge and truck traffic cannot travel the Mackenzie River or Dempster Highway, airplanes are the main freight mover to the north. Oversized cargo loads (those which are too large for the Electra or 737) are frequently flown to Tuk or McKinley Bay by Lockheed L-382 Hercules freighters chartered from Pacific Western Airlines or Northwest Territorial Airways.

To ensure that flight operations suffer a minimum of downtime due to weather, all airplanes and helicopters used by the industry are equipped for IFR (Instrument Flight Rules) flying. The helicopters which shuttle people between onshore and offshore are twin engined, usually with two pilots on board and are equipped with state-of-the-art navigation aids.

Passengers stepping off the Electra or 737 in the Delta are usually whisked, within 30 minutes, to their working location on a drillship or artificial island in the Beaufort. To transport large numbers of oil workers to their work location, many types of helicopters are used; the largest is the Sikorsky S-61, which seats 26 people, followed by the Aerospatiale Super Puma, carrying up to 17, the Sikorsky S-76, seating 12, the Bell 212, seating 10, and the smallest and newest machine, the Messerschmitt-Bolkow-Blohm BO-105, which seats four and serves as a general purpose helicopter. In December, 1980, one of the world's largest helicopters for industrial use was used to move a full size drilling rig to an offshore Esso artificial island location in the southern Beaufort Sea. These Sikorsky skycranes are capable of lifting and transporting sling-loads of up to 20,000 lbs.

Bulky cargo which cannot fit into smaller aircraft is flown to the Beaufort in Lockheed L-382 Hercules freighters, such as this model which belongs to Northwest Territorial Airways. Photo by G. Watson.

Helicopters are essential to support offshore operations, and a variety of types, such as this Sikorsky S-76, are flown in the Beaufort Sea region, landing on the drillship platforms and artificial islands. Photo by G. Watson.

The latest technology in aerospace navigation and IFR flight is employed to support industry activities. For example, the Tuktoyaktuk airport is equipped with an MLS (Microwave Landing System). A new generation of MLS was recently approved by ICAO (International Civil Aviation Organization) as the future standard for major airports around the world. MLS will eventually replace the older ILS (Instrument Landing System) at major airports, but much of its usage today is in support of oil exploration and production activities - whether in the Beaufort Sea or the North Sea. The system provides greater flexibility and higher accuracy during the approach and landing phase than the old ILS system which was designed just after World War Two.

The airplanes and helicopters are equipped with a VLF (Very Low

Canadian helicopter companies such as Okanagon provide charter services to the oil industry in the Beaufort with helicopters such as the Aerospatiale Super Puma (taking off with workers for an offshore site), or the Bell 212. Photo by W. Ralph.

Commonly used aircraft for the local flying in the Beaufort are the DeHavilland Twin Otter (on the right), and the Beechcraft King Air, which is utilized, among other things, for ice reconnaissance and aerial photography in the summer months. Photo by W. Ralph.

Frequency) navigation system, in addition to the more common ADF (Automatic Direction Finder) and VOR/DME (Victor Omni Range/Distance Measuring Equipment) equipment, which allows the pilots to navigate to accuracies of a mile or less over substantial distances. This is a valuable aid in a region which does not have radar control from the ground, as is common at southern airports like Calgary or Toronto. The airplanes and helicopters are also equipped with weather radar. Radar transponders are fitted to drillships and offshore helipads to allow the pilots to identify the landing site on their cockpit radar screen.

As a result of the many navigation and communications systems installed by the industry, and the comprehensive training programs instituted by the companies' aviation departments, aircraft and helicopters are able to fly to the same standards of safety and instrument landing limits as in radar controlled terminals located at many Canadian communities. Helicopters flying to offshore sites can navigate and land in weather conditions as low as those allowed for aircraft in southern Canada.

Aircraft support exploration acitivities in other ways as well. The DeHavilland Twin Otter, a Canadian designed, twin engined turboprop STOL (Short Take-off and Landing) transport, is widely used in the oil industry, and provides local airlift capabilities between shorebase sites. Northerners working for the oil companies are flown to their home communities in Twin Otters, or smaller fixed wing aircraft, in the same manner as southern based workers are rotated to their homes in jet transports.

Aerial ice patrol and surveillance provides an essential contribution to operational safety in the north. Several aircraft are employed, or chartered, during the summer months to keep track of ice break-up and ice movement. Aerial pictures are taken frequently using a SLAR (Side Looking Airborne Radar) system, which can produce high-resolution images of the ice in the Beaufort, at night, and through cloud cover. This aerial support is also backed up by satellite pictures which can provide geographic overviews, in vivid detail, of the Beaufort Sea, Northwest Passage and Amundsen Gulf regions. The information is essential to safe navigation by the large marine fleet that works in the region.

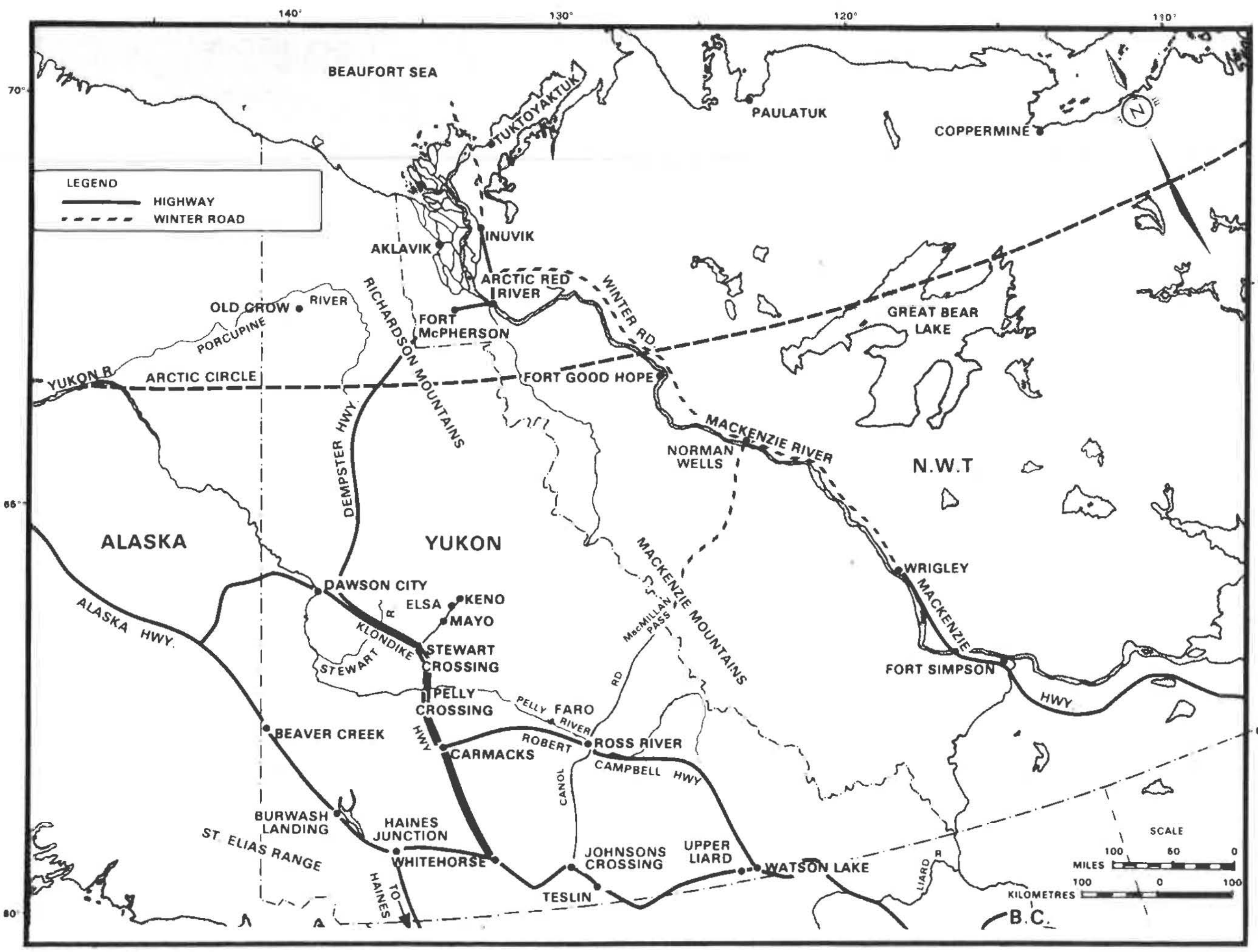
Without aircraft and helicopters Beaufort Sea transportation would be a laborious and slow process - with aviation services the time to bring those energy resources to production is immeasurably shortened. Canada was, more than any other country, opened up by aviation and the Arctic region was extensively explored and mapped from the air. Aircraft will continue to make a major contribution to the development of the Beaufort's hydrocarbon resources that Canada so vitally needs.

Supply Lines to the Beaufort Sea

The Story Of Logistical Support for Northern Exploration

An offshore drilling and exploration program like that in the Beaufort Sea would not be possible without a pyramid of logistical support services, linking the Arctic region to southern resupply centres, and sending an orderly stream of equipment, perishable goods, drilling supplies, fuel and other material to the Mackenzie Delta. All modes of transportation are used to resupply the Beaufort operations including trucks driving over the Dempster Highway and winter ice roads, barges towed up the Mackenzie River, ocean going ships and large transport aircraft and helicopters. In the future more and more ships will be sailing through the Bering Strait, bringing large quantities of goods in bulk.

The most important transportation mode today, both in terms of volume, cost effectiveness and weight transported, are the barges which are loaded at Hay River, N.W.T. and travel north along the broad Mackenzie River. As an example of the scale of yearly requirements, during 1981 one of



This map illustrates the road and river routes to the Beaufort region. The barge traffic originates in the south at Hay River, with trucks leaving Dawson City to travel on the Dempster Highway.

the major operators, Dome Petroleum, moved 160,000 metric tons of cargo to the region, 80% of which travelled by barge. Since barge transport rates are lower per kilogram than any other method, much of the oil industry's heavy equipment and supplies are sent north in this way. Typical of the commodities handled are fuel, barite, cement, drillpipe, drillrigs, dredge pipe casing and chemicals.

However, unlike many offshore operations in temperate climates, the oil companies in the Beaufort Sea and Mackenzie Delta must transport their cargo during those short periods of the year when weather conditions allow. For example, although barges are essential for resupply, they can travel on the Mackenzie River only between mid-June and mid-September, the short period when the river is not frozen.

In the vernacular of the space age, the Beaufort region has a "narrow supply window", and this "window" dominates all the transportation modes other than aircraft. Year round resupply capability is dependent upon aircraft and they are relied upon when other means cannot be used. Supplies which are not barged to the north travel mainly by trucks using the Dempster Highway, a 670 kilometre (450 mile) long gravel road connecting Dawson City, Yukon to Inuvik, N.W.T. via Fort McPherson and Arctic Red River. The highway was completed in 1979 and has had an important impact on resupply operations. However, it is not a year-round highway; it is open for traffic only from June to October and from mid-December to mid-April. During the summer period ferries carry the trucks across the Peel and Mackenzie rivers, and in the winter there are ice bridges across these rivers as well as an ice road that extends the Dempster from Inuvik to Aklavik and Tuktoyaktuk, the main industry operations centre for the Beaufort Sea.

The trucks travelling the Dempster and Mackenzie highways include large semi-trailers and tandem units which carry about 18,000 kilograms (40,000 pounds) of goods. The most common products carried by truck are operating supplies such as repair and maintenance equipment, perishable goods, clothing, tools and spare parts. In the summer months, a tug-barge express system carries these operating supplies, as well as trailers from the Inuvik freight centres to Tuk and McKinley Bay. For many years, Esso has moved its drill rigs over land and across ice.

Trucks are also used in the winter months to transport supplies from Tuk base on an ice road to McKinley Bay. Fuel and drilling supplies for McKinley are moved by

Large barges which carrry much of the industry's supplies are shown at anchor on the broad Mackenzie River. Photo courtesy of G. Kruk.

barge and supply vessels in the brief ice-free period. High priority freight for the region is flown in aircraft as large as the Lockheed Hercules and Boeing 737. They may land at Tuktoyaktuk with cargo or, in the winter months, on an icestrip in the harbour at McKinley Bay. Smaller fixed wing aircraft shuttle from Inuvik to Tuk with supplies on a regular basis, or to other advanced staging areas which have temporary ice strips.

Due to the restrictions of climate, logistical support for the Beaufort region demands careful advance planning. A detailed forecast of annual drilling programs is necessary to determine quantity and types of material required, and to formulate a schedule of resupply operations. Planning is essential for cost-effective logistical support, since goods which do make it to the bases at Inuvik, Tuktoyaktuk and McKinley Bay by barge and truck may have to be flown in by aircraft, at much greater cost. Naturally, the typical variations in Arctic freeze-up and thaw from year to year do not make the logistical planner's task an easy one.

Every year that the industry has been in the Beaufort region, the tonnage of cargo being transported has increased significantly. In 1981 there was major activity in the building of artificial islands, requiring large amounts of rock and gravel, and about 15,000 tons of rock were transported from the Inuvik area to offshore sites. Some 25,000 tons of boxed and bulk chemicals, principally barite and cement additives, were also required in that year for direct use in drilling wells. These figures represent only a portion of the industry total for the three major Beaufort operators, Esso, Gulf and Dome.

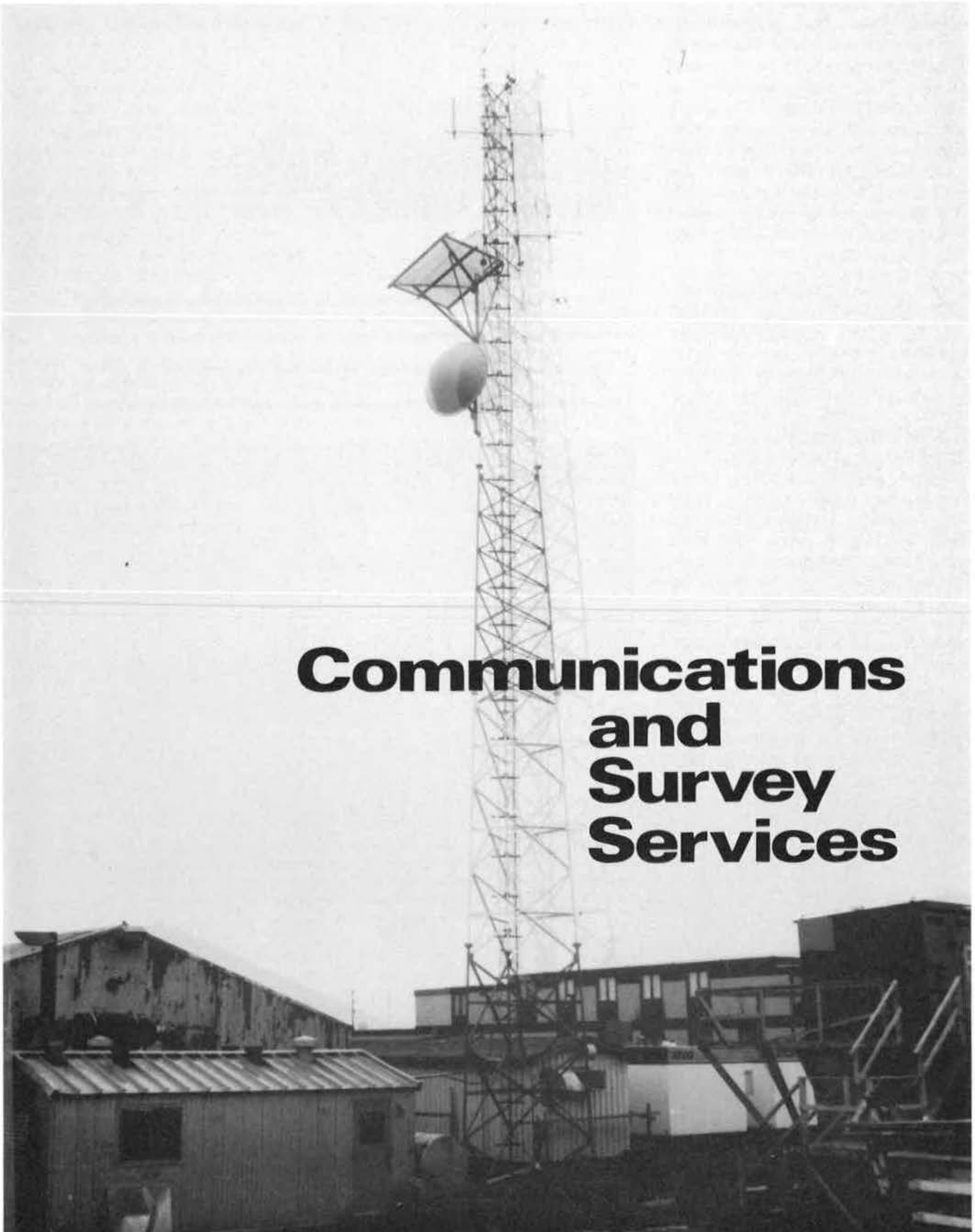
Offshore operations demand a wide variety of specialized equipment, industrial tools and parts. The Beaufort Sea operations receive engine components shipped from England, ships' anchors from Belgium and dredge pipe from Holland, as well as other goods from around the world. The shipping and receiving of goods from all over the world requires bonded warehousing facilities as well as proper adherence to customs and excise regulations. To coordinate and control logistical operations in the north, a computer system has been developed by one of the major operators, Dome, which is called the on-line integrated materials management system. It keeps track of inventory and the stock of replenishable items, and thereby provides a feedback system between the headquarters and planning departments, the operational bases and drillships in the Beaufort region.

Offshore operations, like armies, are only as good as their logistical support; without backup and replenishment they would quickly grind to a halt. Support for the Beaufort Sea exploration program is made more difficult by the Arctic climate, but the many years of successful exploration underwrite the fact that supply links to the north are maintainable, despite the adversities of the environment and the great distances.

Since the late 1960s overland travel on the Arctic tundra has supported the drilling operations in the Delta and Beaufort Sea coastline. To protect the tundra and underlying ice rich permafrost, vehicles with low pressure tires or wide tractor treads are used.

This photo shows a six-wheel-drive unit originally designed for use in the desert. It is capable of pulling as many as three 16 ton sleighs, each of them holding 30 tons of cargo, through one metre deep snow. Photo courtesy of Esso.

For cargo hauls where snow is too deep for the six wheeled trucks, tracked vehicles such as the one illustrated in this photograph are used. They travel at a top speed of about 10 kmh, pulling five 30 ton sleighs, as well as carrying another 30 tons on the back of the main vehicle. Photo courtesy of Esso.



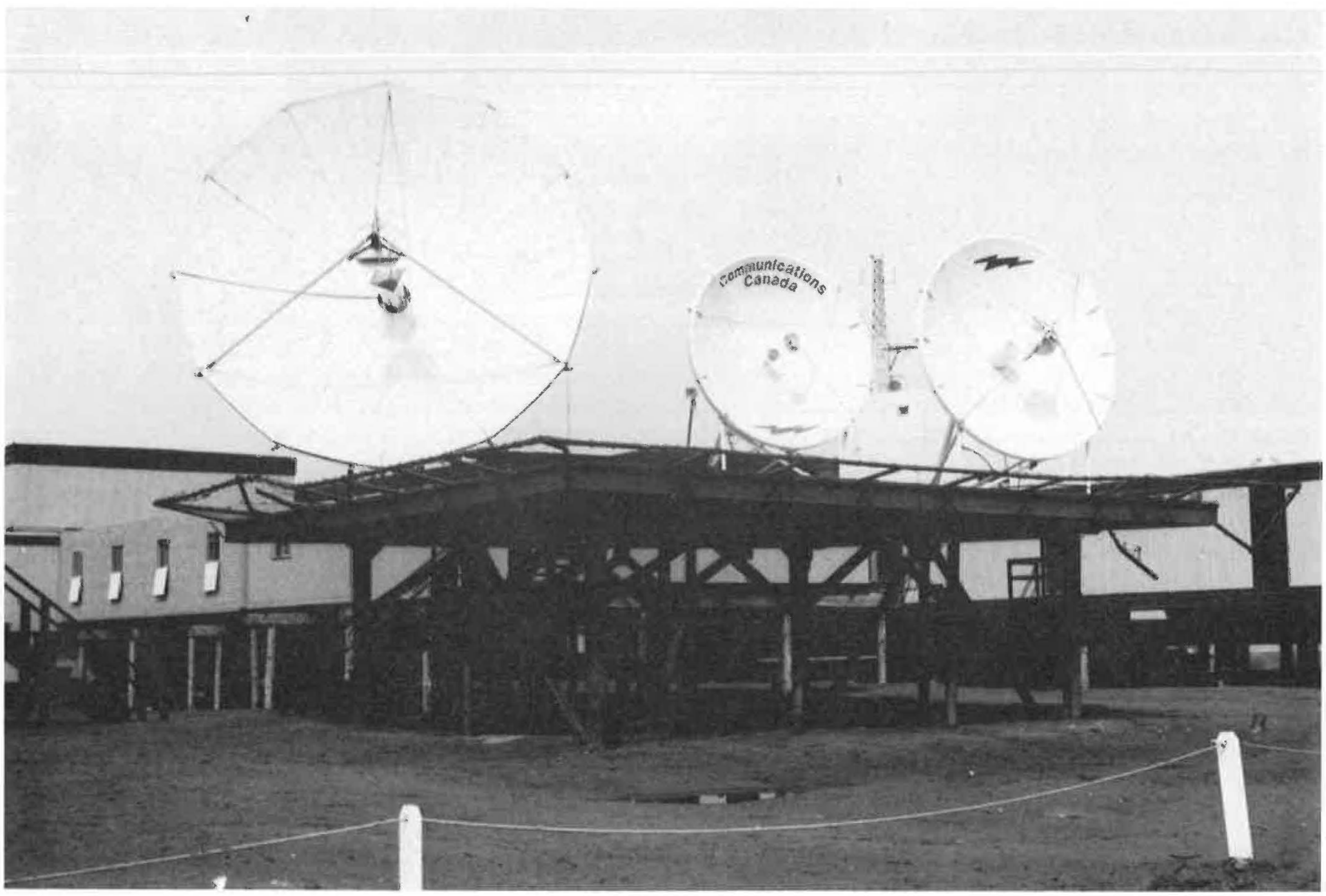
Communications and Survey Services

There are many technical support services vital to an offshore exploration program and two of the most important, but often overlooked, are communications and survey. Providing communications, both voice and data links, for oil industry operations is more difficult in an isolated region such as the Beaufort and oil companies have had to draw upon several kinds of new communications technology. The variety of traffic, whether it be boats, airplanes or trucks, as well as the changing positions of the drillships and other offshore stations, and the heavy demand for continuous links between onshore, offshore and southern head offices, dictate that no single method of communication will suffice.

The Mackenzie Delta and Beaufort Sea area is linked to the rest of Canada by Northwest Tel's telephone system and this provides an important element in the communication chain. This company also provides and maintains a mobile telephone system for the Delta region, but for offshore communications the oil companies have developed an additional network. Initial exploration in the north relied upon radio-telephones, but in 1974 government licensing was obtained by Esso for the first private multi-channel radio network. This was the first transportable telephone system licensed in Canada, and extended beyond the existing Northwest Tel facilities.

The major offshore communications method is microwave combined with VHF (Very High Frequency) radios. From Tuktoyaktuk a microwave relay system extends along the Beaufort Sea coastline; since it is a line-of-sight system, its range is limited to approximately 80 kilometres (50 miles). VHF radios extend coverage an additional 120 kilometres (70 miles), and for longer distances than this, HF (High Frequency) radios may be used. The radio room at Dome's Tuk base has two duplex HF channels as well as three marine VHF patch channels which interface to the telephone network. In addition, there are marine VHF and HF SSB (Single Side Band) radios for communication between ships.

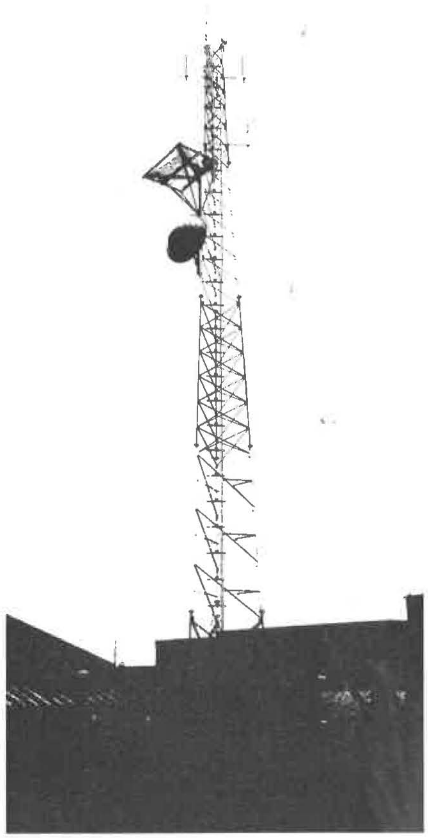
Many of the drillships, work barges, as well as the artificial islands can be telephoned via the standard telephone network, since they have a telephone land line connecting VHF and HF to radio links. For the transmission of non-voice information, such as data from offshore drilling operations, the industry has drawn upon the latest technology of satellite communications. Beaufort Sea operations have a relay link via some of the ANIK series satellites, and can transmit information from the north via a large antenna dish to



Satellite voice and data communications links are becoming increasingly important and cost effective in the Beaufort operations. Photo by W. Ralph.

head offices located in Calgary. In addition, Tuk base receives television programs via satellite. Another vital service provided by the comminications system is installation and maintenance of navigation aids for both air and sea traffic, including radar sets, gyro compasses, NDBs (Non Directional Beacons), and air to ground communications.

Satellite linkage is particularly important for meteorological forecasting and ice reconnaissance in the Beaufort Sea. A NOAA (U.S. National Oceanographic and Air Administration) 7 satellite is used to transfer satellite imagery to the Beaufort Sea from spring break-up through to the end of the drillship exploration season. Later in this decade it is expected that satellite coverage will allow much more comprehensive images of the north than are obtained at present. It is anticipated, as well, that an increasing amount of communications and marine navigation will be conducted with the aid of satellite links.



Survey Services - The Navigation and Positioning of Vessels, Islands and Dredges

All of the companies in the Beaufort region require extremely accurate positioning to conduct exploration and construction programs. This support requirement is called survey, although it involves much more than what one typically thinks of as land survey in the south. A survey group is responsible for navigation/positioning for drilling, dredging and marine operations generally. One of the most demanding tasks in exploration is positioning the drillships and artificial islands in the precise locations over potential oil deposits. Accuracies down to two or three metres over long distances of hundreds of kilometers are necessary. An idea of the demands placed upon survey skills can be gained when one realizes that a subsea will site, at the point where it protrudes above the ocean floor, is one metre in diameter. Well sites which are suspended and capped for completion at a later date must be found again in future drilling seasons. Finding a one metre pipe stem in the Beaufort Sea is a demanding exercise requiring high technology survey methods.

Positioning offshore is accomplished by a mathematical process call trilateration, the measurement of two or more distances from know points on land. This method enables a drillship to position itself over a well site. It is equally important for locating a dredger in a precise position for the purpose of excavating a shipping channel or building an island. It can also provide the captain of a seismic vessel with the precise navigation tracking called for to complete a seismic survey of the substrata.

Trilateration is achieved by the use of towers located on the shoreline which transmit radio signals. By measuring the radio signals, a computer can calculate the exact location of a site. Due to the accuracy called for, the computer must adjust for the curvature of the earth in measuring the distance travelled by the radio signals.

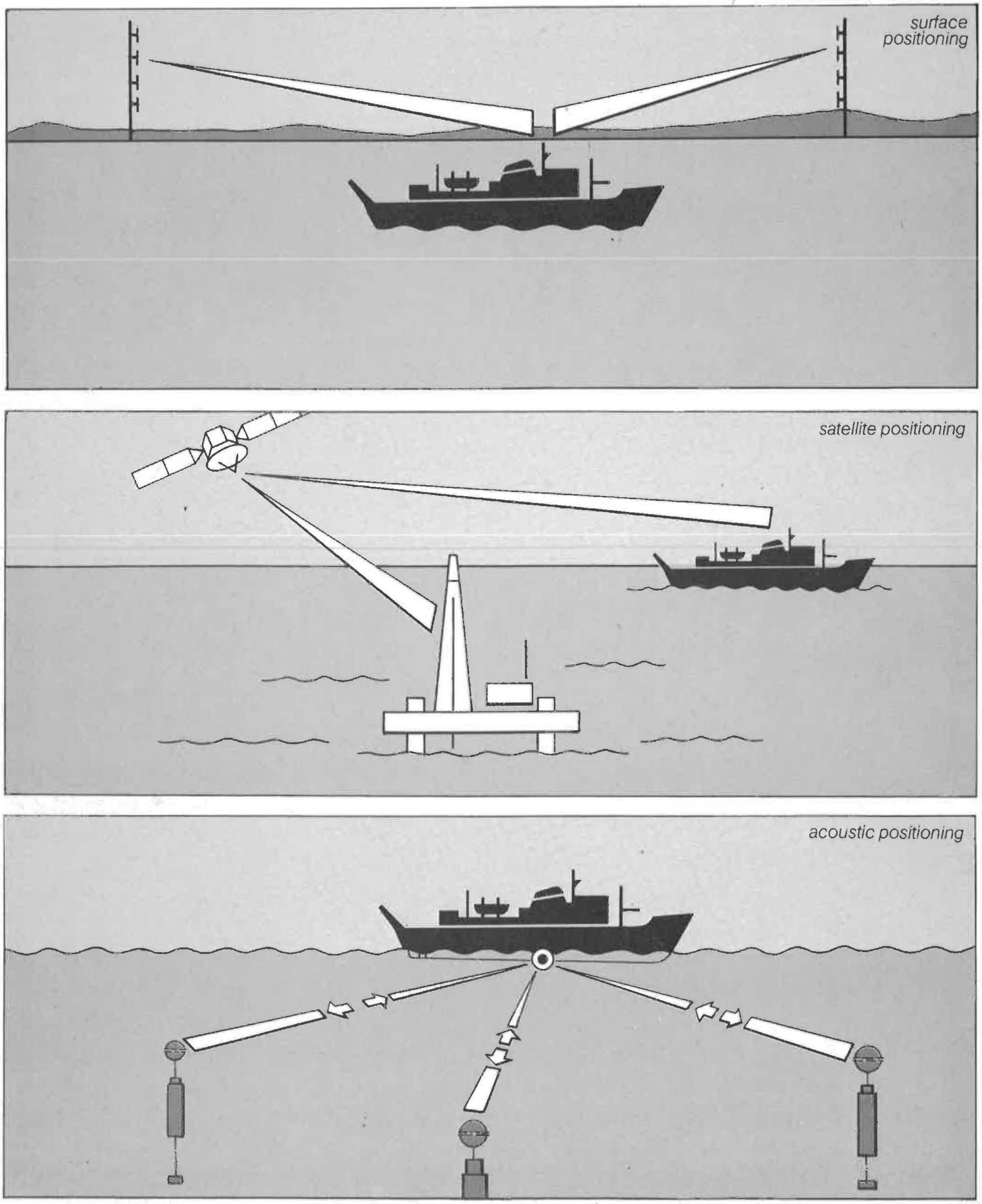
Different range location systems are used by the industry for positioning and navigation. A long range system, working in the 1.6 Mhz band, is called Argo; it can measure to within 15 to 20 metres over distances of several hundred kilometres. A shorter range system called Syledis, in the 436 Mhz band, provides survey crews with a 2 to 5 metre accuracy. However, to find a subsea drill pipe requires even better accuracies, and for this task subsea acoustic systems are employed. The underwater visibility in the Beaufort is poor and makes it difficult for divers to find well sites on the ocean floor, unless their exact location is pinpointed with the aid of acoustic scanners.

Survey navigation and positioning is important throughout the Beaufort Sea, not only for drilling, but for marine vessel movements. The Beaufort is rather shallow in most locations and even in dredged channels the clearance for vessels, particularly deep draft ships, is minimal. It is particularly important for ships to manoeuvre precisely in the shallow waters of McKinley Bay to avoid grounding out on the sandy bottom. One of the duties of survey teams is to place marker buoys in place for navigable channels in the harbours as well as the surrounding areas.

To assist vessels to stay within narrow corridors and manoeuvre in confined harbours, they are equipped with a Mini Ranger system which has a range of approximately 30 kilometres (19 miles). Automatically operated shore-based towers transmit signals which give the exact location of the vessel, displaying it on a TV screen in a moving map format.

As the result of this technology, navigation and positioning in a remote region of the Arctic is as precisely accomplished, if not more so, than would be the case in extensively populated regions of Canada. Despite the image of the north as a trackless region, devoid of signposts, the industry is able to work and move around there with greater knowledge and precision than in many more developed locations.

These sketches summarize the different methods employed to provide positioning and navigation for vessels, drillships and subsea operations. Shorebased towers, satellites and underwater acoustics all play an important part in the search for oil.



This aerial view of Dome Petroleum's base of operations at Tuktoyaktuk was taken during the brief Arctic summer. At the left can be seen the large fuel storage tanks and yard area. The white buildings are warehouses and repair shops, and the long cream coloured buildings are living quarters.